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14. ABSTRACT
The goal of the proposed research is reconstruct the three-dimensional regional electron density profile of Earth's ionosphere with spatial resolution of better than 10 km and sub-minute temporal resolution. We intend to combine data from traditional sources (GPS) with data from the Very Large Array (VLA). The VLA has ~10x better sensitivity to total electron content (TEC, or chord integrated density) in the ionosphere that does GPS. The proposal funds the research efforts of a graduate student.

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Final Report:

Three Dimensional High-Resolution Reconstruction of the Ionosphere over the Very Large Array

Award: FA9550-09-1-0016
15 December 2010
Christopher Watts, ECE Dept., University of New Mexico

Summary of original proposal

The goal of the proposed research is reconstruct the three-dimensional regional electron density profile of Earth's ionosphere with spatial resolution of better than 10 km and sub-minute temporal resolution. We intend to combine data from traditional sources (GPS) with data from the Very Large Array (VLA). The VLA has ~10x better sensitivity to total electron content (TEC, or chord integrated density) in the ionosphere that does GPS. The proposal funds the research efforts of a graduate student.

Advances during the past year

This past year work focused on continued processing of the data from the CRICkET campaign (Combined Radio Interferometer-COSMIC Experiment in Tomography) of September, 2007 (see previous report). CORS data from this period was analyzed over the Southwest region where the VLA is located (that cover all of New Mexico, Arizona, western Texas, and southern California.). A movie was made of the evolution of the ionosphere from this date, a still shot of which is shown in Fig. 1 below.

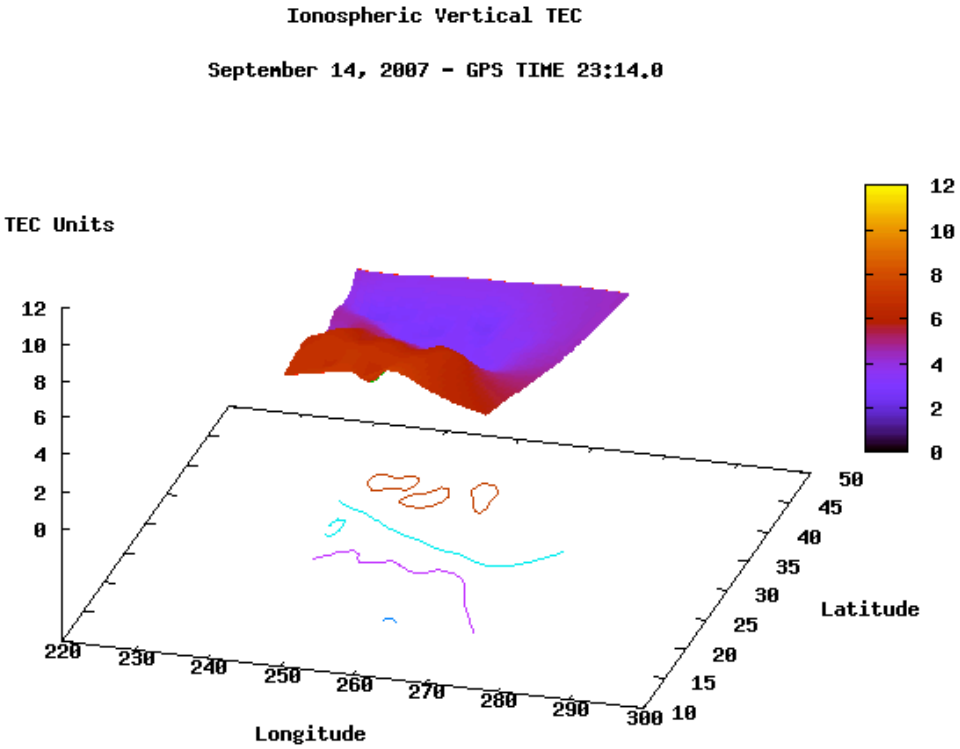

Fig. 1. Vertical TEC map over the southwest USA during the CRICkET experimental campaign time, Sept. 14, 2007.

The goal of this phase of the project was to confirm the presence of a Traveling Ionospheric Disturbance (TID), seen in VLA data, in the GPS data (see publication below). Tantalizing hints of corroboration are seen, however quantitative analysis is still ongoing to definitively confirm the same event in both data sets.

Work also began on using a different tool to analyze the VLA data. *Obit* is a sophisticated package to visualize radio astronomy data. For our purposes, it includes algorithms to compensate for the ionosphere. These "cleaning" algorithms enhance radio astronomy images by successively forcing point sources to appear as single pixels in the image. The goal of this project is to use the "noise" data, which is removed as part of the cleaning process, to learn something about ionosphere, which is the dominant source of the noise. A script was successfully developed to extract the noise data in a usable format. First results are still under interpretation.

Farther afield, a collaboration was begun with the ionospheric group at the LOFAR radio telescope project in the Netherlands. Dr. Watts visited the LOFAR site in June, 2010 and met with several key players. The two long wavelength telescopes (LWA and LOFAR) take different approaches to compensating for ionospheric corruption in the astronomy data. The work is largely complementary, and there is good opportunity for fruitful collaboration. A similar collaboration was also begun with the LOFAR group working at the Max Planck Institute for Radio Astronomy in Bonn, Germany. Dr. Watts was on sabbatical for much of 2010 and was able to establish close ties with the group. As a result, we are planning to move ahead with a Beysian analysis technique for extracting ionospheric information from radio astronomy data. This will be in parallel with the current work on the VLA data.

Recent Publications

K. F. Dymond, C. Watts, *et al.*, *A medium-scale traveling ionospheric disturbance observed from the ground and from space,* Radio Science **46** RS5010 (2011).